PATENT ABSTRACTS OF JAPAN

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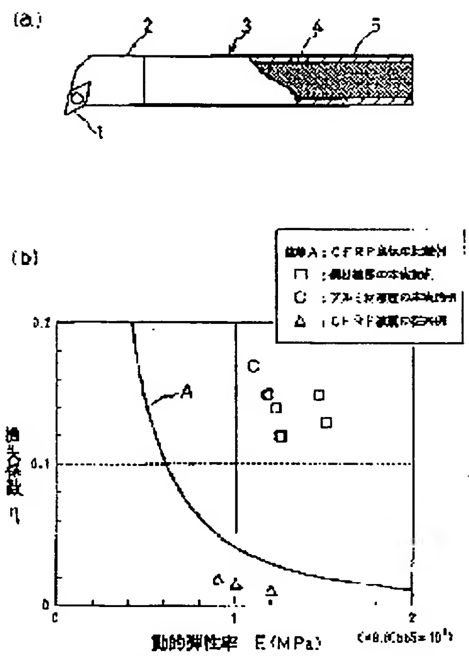
(54) BORING BAR

(57)Abstract:
PURPOSE: To provide a boring bar capable of effectively suppressing chatter vibration and boring a work with high machining accuracy even when L/D is made larger.
CONSTITUTION: This boring bar is provided with a head section 2 having a cutting tip 1 at the top of an axial shank section 3, and the shank section 3 is coated with a film layer 5 made of a steel material or an aluminum material having the bending elastic modulus higher than that of fiber reinforced plastic on the outer periphery of an axial main body 4 made of fiber reinforced plastic. The shear deformation of the plastic matrix material constituting the main body 4 of the shank section 3 is restrained by the film layer 5 on the outer periphery, and high rigidity and a high loss factor can be concurrently secured. Even when L/D is made larger, the occurrence of chatter vibration is suppressed, and a work can be bored with high accuracy.



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CLAIMS

[Claim(s)]
[Claim 1] the boring bar which comes to prepare the head section holding a cutting chip at the tip of the shaft-like shank section -- the boring bar characterized by coming to have the enveloping layer which it is, and said shank section is covered by the periphery of the body of the shape of a shaft which consists of fiber strengthening composite, and this body, and consists of high elasticity material with a bending modulus of elasticity higher than said fiber strengthening composite.
[Claim 2] The boring bar according to claim 1 with which an enveloping layer consists of metal material.
[Claim 3] The boring bar according to claim 1 with which an enveloping layer consists of ceramic material.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention is a thing which is used in case boring cutting is performed in a machine tool and which carries out boring bar Seki.
[0002]
[Description of the Prior Art] With the boring bar used in case boring processing of the work piece is carried out in a machine tool, it becomes easy to generate chatter vibration at the time of processing, and this chatter vibration reduces the finishing precision of a work-piece processing side, or becomes with the cause of reducing the life of the cutting chip at the tip of a bar as the ratio of ejection die-length L from the fixed part of this bar to the path D of that bar, i.e., ratio of length to diameter, becomes large. Then, in the former, when ratio of length to diameter became large, generating of chatter vibration was avoided using the superhard bar which consists of rigid high cemented carbide material, various kinds of vibrationproofing bars which allotted the oscillating absorber and the vibrationproofing device to the body of a bar.
[0003] Moreover, in order to raise the rigidity of a boring bar as indicated by JP,5-39806,U, there are some which used fiber strengthening composite as an ingredient of the body of a bar. This boring bar (JP,5-39806,U) As shown in [drawing 5 R> 5], the chip section (21) which holds a chip at a tip It has the steel core (20) of the shape of a shaft which prepared the clamp section (22) in the back end side. To the perimeter between the chip section (21) of this steel core (20), and the clamp section (22), and carbon fiber reinforced plastic It considers as the configuration which covered the shell (23) which consists of (calling it CFRP for short hereafter). Since the rigidity of CFRP of the shell (12) is high, and the resonant frequency of the body of a bar is high since specific gravity is small, and CFRP is large compared with steel, the loss factor which shows a periodic-damping property The loss factor of the whole bar also becomes large compared with a steel bar, and is enabling control of chatter vibration by this.
[0004]
[Problem(s) to be Solved by the Invention] However, there are the following troubles in the boring bar by the above-mentioned conventional technique. That is, in said superhard bar, since the weight per unit volume of the cemented carbide material to be used is large, if a bar becomes a major diameter, while weight will become excessive, it becomes expensive. Moreover, at the time of use, the fine adjustment of said vibrationproofing bar is needed intricately [structure] at an expensive price.
[0005] On the other hand, the rigidity of the matrix material between fiber becomes to some extent low, and in the condition that shear deformation arises in a matrix material, fiber strengthening composites, such as CFRP, have the property that the loss factor of the fiber strengthening composite becomes large, when the own loss factor of a matrix material is large. Moreover, the shear deformation of this matrix material has the property that a core becomes large, in the direction of a cross section of this fiber strengthening composite. And the relation between the loss factor of fiber reinforced plastics own [when changing the dynamic modulus of longitudinal elasticity of the matrix resin of fiber reinforced plastics] and rigidity (dynamic modulus of longitudinal elasticity) has the remarkable fall of rigidity as shown in the graph of

[drawing 4], when it has the relation of an inverse proportion mostly and a loss factor (periodic-damping property) is given highly, and when steel materials and the rigidity more than equivalent are given, the property that a loss factor falls remarkably has it. On the other hand, it is considering as the structure which covered the shell which becomes the perimeter of a steel core from fiber reinforced plastics with said conventional boring bar using fiber reinforced plastics, such as CFRP. Therefore, since steel exists in the cross-section core which becomes the largest [a shear strain] on structure, a loss factor cannot be raised effectively. Moreover, although rigidity of fiber reinforced plastics own [this] becomes low and the rigidity of the whole bar will be secured with a steel core when the fiber reinforced plastics which took the large loss factor are used in order to compensate this, since this core is in a cross-section core, its cross-section second moment will be low, and rigidity will become low. Therefore, with the structure of this conventional technique, when ratio of length to diameter is enlarged more, unless that rigidity and loss factor are raised collectively, the problem of it becoming impossible to suppress chatter vibration effectively occurs.
[0006] This invention aims at offering the boring bar which can control chatter vibration effectively, even when high rigidity and a high loss factor are securable for coincidence and ratio of length to diameter is therefore enlarged more in view of the trouble of the above-mentioned conventional technique.
[0007]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention is considered as the following configurations. namely, the boring bar with which the boring bar concerning this invention comes to prepare the head section holding a cutting chip at the tip of the shaft-like shank section -- it is, said shank section is covered by the periphery of the body of the shape of a shaft which consists of fiber strengthening composite, and this body, and it is characterized by coming to have the enveloping layer which consists of high-elasticity material with a bending elastic modulus higher than said fiber strengthening composite.
[0008] Moreover, the above-mentioned enveloping layer shall consist of metal material.
[0009] Moreover, the above-mentioned enveloping layer shall consist of ceramic material.
[0010]
[Function] As mentioned above, although a loss factor becomes large in the condition that shear deformation arises in the matrix material between fiber, fiber strengthening composite Since an inverse proportion is almost related, when a loss factor (periodic-damping property) is given highly, the loss factor and rigidity (dynamic modulus of longitudinal elasticity) Since the fall of a loss factor becomes remarkable when a rigid fall becomes remarkable and rigidity is raised conversely, if it remains as it is, a certain limitation produces rigidity and a loss factor to raise to coincidence. It sets to the boring bar of this invention here. Since the periphery of the body which consists of fiber strengthening composite of the shank section is covered with the enveloping layer which consists of high elasticity material with a bending elastic modulus higher than the fiber strengthening composite of this body The shear deformation of the matrix material of the fiber strengthening composite which constitutes this shank section body by restraining on the direction periphery of a cross section Since the rigidity of this fiber strengthening composite can be raised and the shear strain of the matrix material in the direction core of a cross section of this fiber strengthening composite is not restrained again Even when a large loss factor can also be taken, namely, the high rigidity of the shank section and a high loss factor can be secured to coincidence and ratio of length to diameter is therefore enlarged more, chatter vibration can be controlled effectively and a work piece can be cut with a sufficient precision.
[0011] Moreover, it is covering the periphery of the fiber strengthening composite which constitutes the body of the shank section with the enveloping layer which consists of metal material with a bending elastic modulus higher than this fiber strengthening composite, or ceramic material. An oil, water, etc. which are used at the time of cutting while high rigidity and a high loss factor are securable for coincidence as mentioned above, For the fiber strengthening composite concerned, the corrosion resistance improvement under an environment which problems, such as corrosion, produce can be aimed at, and fiber strengthening composite is protected from the damage which has occurred during cutting and depends ** etc. again, and

extension can also plan useful life longevity.
[0012]
[Example] The example of this invention is explained with reference to a drawing below. [drawing 1] the (a) Fig. shows the configuration of one example of the boring bar concerning this invention -- it is a fracture side elevation a part. [Drawing 1] The boring bar of this example shown in the (a) Fig. is a cutting chip (1) at the tip of the shaft-like shank section (3). The head section tabular [rectangular] to hold (2) It comes to prepare.
[0013] Moreover, the shank section (3) Body of the shape of a shaft which consists of a CFRP (carbon fiber reinforced plastic) (4) Enveloping layer which consists a periphery of metal material (5) It comes to cover. And this shank section (3) At a tip, it is the head section (2). It is attached by welding.
[0014] In this operation, roving which comes to bundle strengthening fiber the number of predetermined is first immersed in a resin tub. Matrix resin is infiltrated into this roving, this is inserted into the metallic conduit of predetermined thickness, and they are the outer diameter of 16mm, and die length. It forms in a 200mm stem. Subsequently Body of the shape of a shaft which consists of a CFRP by heating this by predetermined temperature and time amount in oven, and stiffening internal resin (4) About a periphery, it is the enveloping layer (5) of metal material. The shank section which it comes to cover (3) It formed. And this shank section (3) It is the head section (2) at a tip. It welded and formed in the boring bar of the above-mentioned configuration.
[0015] Moreover, body (5) CFRP is strengthening fiber. 49033MPa (50000kgf/mm2) Petroleum pitch system carbon fiber XN-50 (GURANOKKU by Nippon Oil Co., Ltd.), the coal pitch based carbon fiber K-135 (diamond lead by Mitsubishi Kasei Corp.), and PAN system carbon fiber M50B (Toray Industries, Inc. make trading card) which have a modulus of longitudinal elasticity were used. moreover -- matrix resin -- "Epicoat 87 (EPOSHIKI equivalent 430)" (shell company make) of EPOSHIKI resin, and a curing agent -- acid anhydride "Epiclon B570" (Dainippon Ink make) and imidazole "epicure EM-24" (shell company make) 100:27.0:2.8 what came out of comparatively and was mixed -- using -- this It heated for 30 minutes at 170 degrees C, and the hardening reaction was made to perform. The modulus of longitudinal elasticity of the strengthening fiber of this CFRP, the oscillation frequency of 1000Hz of matrix resin, a 25-degree C modulus of longitudinal elasticity, and a loss factor are shown in [Table 1].
[0016]
[Table 1]

	縦弾性率 MPa	損失係数 η
強化繊維	490333 (50000kgf/mm^2)	———
マトリックス樹脂	167 (17kgf/mm^2)	0. 26

[0017] moreover, body (4) Enveloping layer (5) of a periphery ****** -- to a metallic conduit elastic modulus 205940MPa (21000kgf/mm2) -- thickness t 0.25mm and 0.35mm -- and -- The steel pipe (an equivalent for S45C) which is 0.5mm, and elastic modulus By 68647MPa (7000kgf/mm2) Thickness t 0.5mm and 1.0mm And aluminum tubing (pure aluminum) which is 1.5mm was used. and these shanks section (3) ******** -- the tip -- the head section (2) Before welding, the following performed evaluation of the rigidity and loss factor.
[0018] The shaft-like shank section (3) It hit in the direction of bending by the boundary condition of both-ends freedom, and asked for the resonant frequency f of the primary bending using FFT (Ono Sokki CF 350) from the wave of the free vibration at that time. Moreover, body at this time (4) The dynamic modulus of longitudinal elasticity ECFRP of CFRP is the following. It asks by [1] formula.
ECFRP=16, 2, L4, and rhoCFRP/DCFRP 2-4.734 ---- [1] -- here, rhoCFRPs are [a diameter and L of the consistency of Above CFRP and DCFRP] die length.
[0019] And each shank section of this example (3) The dynamic modulus of longitudinal elasticity

E is the following. It asked by [2] formulas.
E=1-/ICFRP- [(K-L3 / 4.734) - (EMETAL and IMETAL)] ---- [2] -- the shank section (3) in which K can be found from the above-mentioned primary measurement natural frequency f here A load rate, ICFRP, and IMETAL Body (4) CFRP and enveloping layer (4) the cross-section second moment of metal material -- it is -- these -- the following [3] - It asks by [5] formulas. Moreover, L is the shank section (3). Die length and EMETAL Enveloping layer (4) It is the dynamic modulus of longitudinal elasticity of metal material.
K=M (2 pi-f), 2 ---- [3] ICFRP=pi/DCFRP 4 / 64 ---- [4] IMETAL =pi- [(DCFRP+2t) 4-DCFRP4]/64 ---- [5] -- here -- M -- the shank section (3) mass and t -- said enveloping layer (4) ****** -- it is the thickness of the used metallic conduit.
[0020] On the other hand, it is each shank section (3) of this example. A loss factor eta asks for a logarithmic decrement delta from the wave of the above-mentioned free vibration, and is the following. It asked from the relation of [6] types.
eta=delta/pi ---- [6] -- while these results are shown in [[Table 2 and 3]] -- [drawing 1] The graph of the (b) Fig. is made to contrast with the thing of the conventional technique, and it is shown in it. In addition, the example which covered the body periphery which [Table 2] becomes from CFRP with the enveloping layer which consists of steel materials, and [Table 3] show the value of the example which covered this body periphery with the enveloping layer which consists of aluminum material, respectively. Moreover, the fiber volume fraction of CFRP is shown Vf% in these tables.
[0021]
[Table 2]

鋼材被覆シャンク部					
繊維体積含有率	Vf 55%			Vf 65%	
層厚さ mm	0.25	0.35	0.50	0.35	0.50
動的弾性率 MPa (参考 kgf/mm²値)	116072 (11836)	121073 (12346)	120475 (12285)	144089 (14693)	148100 (15102)
損失係数 η	0.15	0.14	0.12	0.15	0.13

[0022]
[Table 3]

アルミ材被覆シャンク部				
繊維体積含有率	Vf 55%			
層厚さ mm	0.5	0.75	1.0	1.25
動的弾性率 MPa (参考 kgf/mm²値)	108373 (11051)	116474 (11877)	120475 (12285)	122377 (12479)
損失係数 η	0.17	0.15	0.14	0.12

[0023] Moreover, [drawing 1] (b) the value plotted by the square mark in the graph of a Fig. This example (it corresponds to [Table 2]) which covered with the steel-materials enveloping layer the body periphery which consists of a CFRP, and the value which plotted by the round mark The result of this example (it corresponds to [Table 3]) which covered this body periphery with the aluminum material enveloping layer is shown, respectively. Moreover, the plot of the trigonum mark The result of the example of the conventional technical **** comparison which covered the periphery of a steel core with the shell which consists of a CFRP is shown, and Curve A shows the value in the stem of the CFRP simple substance shown in the graph of [drawing 4].
[0024] in addition, the dynamic modulus E of the stem of a CFRP simple substance -- the above Second-moment ICFRP and IMETAL The following [7] -- and -- It is setting from [8] types and asks. [in / in the dynamic modulus E of the conventional technique which was searched for from

[1] type and covered the steel core periphery with the shell of CFRP / the aforementioned [2] formula]
ICFRP=pi- [(DMETAL+2tCFRP) 4-DMETAL 4] / 64 ---- [7] IMETAL = pi-DMETAL 4/64 ---- [8] -- here -- DMETAL The diameter of a steel core and tCFRP are the thickness of CFRP shell.
[0025] [Table 2] [table 3] and [drawing 1] (a) As shown in the graph of a Fig., in the thing of this example, the big value which was impossible for the modulus of longitudinal elasticity and the loss factor with the conventional technique was realizable.
[0026] Subsequently, each shank section of above-mentioned this example (3) At a tip, it is the head section (2). While welding, it is this head section (2). Cutting chip (1) It attached, and considered as the boring bar of one body, and the following evaluation trials and boring cutting trials were performed about the boring bar (thing equipped with enveloping layer thickness 0.35mmm and the shank section with a diameter of 16mm) which has a steel-materials enveloping layer of them. Moreover, for the comparison, the boring bar furnished with the above, the same head section, and a cutting chip was prepared for the shank section of a carbon steel (S45C) simple substance with a diameter of 16mm, and the trial of the above and these conditions was performed in it.
[0027] First, it is the amount of ejection about the above-mentioned boring bar. 96mm It fixed by the support at one end carried out, and asked for the resonant frequency and loss factor in this condition. The measuring method of a natural frequency attached the acceleration sensor at the tip of a cutting chip, and asked for the natural frequency f of the primary bending using FFT (Ono Sokki CF 350) from the signal of a free vibration wave acquired by hitting the cutting chip tip in the direction of bending. Moreover, a loss factor eta is described above like said shank section. It asked from [6] types. The result is shown in [Table 4].
[0028]
[Table 4]

	固有振動数 Hz	損失係数 η
本実施例	9 5 0	0. 1 1
比較例	1 1 1 2	0. 0 3

[0029] As shown in [Table 4], as for boring bar ratio **** of the example of a comparison which the boring bar of this example equipped with the shank section of a steel simple substance, and a natural frequency, the loss factor showed the value with this sharply as big level **** as about 4 times mostly.
[0030] Then, they are 300rpm and the amount of slitting about the rotational speed of a work piece with these boring bar (the amount of ejection of 96mm). 0.1mm and feed rate By the cutting conditions set to 0.08mmrev, the boring cutting trial was performed and the vibration acceleration at the tip of a cutting chip was measured. the result -- [drawing 2] the (a) Fig. -- and -- It is shown in the graph of the (b) Fig. In addition, the graph of the (a) Fig. of [drawing 2] is the boring bar of this example, (b) The graph of a Fig. shows the check ****** wave at the time of boring cutting with each boring bar of the example of a comparison.
[0031] [Drawing 2] (b) As shown in the graph of a Fig., the boring bar of the example of a comparison has started comparatively big check ******, and it was checked to this that the boring bar of this example has not caused chatter vibration, and can control effectively the chatter-by this vibration under boring cutting in the boring bar of this example as shown in the graph of the (a) Fig.
[0032] As stated above, in the boring bar of this example, by restraining the shear strain of the matrix material of CFRP which constitutes the body of the shank section by the enveloping layer of a periphery, high rigidity and a high loss factor could be realized to coincidence, the chatter vibration under boring cutting could be controlled effectively, and, thereby, the effectiveness which was excellent in this invention was able to be checked. furthermore , the corrosion resistance improvement under an environment which problems , such as corrosion , produce can

aim at , and fiber strengthening composite protect from the damage which have occur during cutting and depend ** etc. again , and extension also plan useful life longevity for the CFRPs concerned , such as an oil use at the time of cutting , and water , by cover the periphery of CFRP which constitute a shank section body from a boring bar of this example with the enveloping layer which consist of a steel materials or an aluminum material .
[0033] In addition, with the boring bar of the above-mentioned example, it is a cutting chip (1). The head section to hold (2) Shank section (3) Although it joined by welding, this is one example, and it is the head section (2). Shank section (3) For example, by taking the structure shown in [drawing 3], it is connectable removable.
[0034] [drawing 3] the (a) Fig. -- and -- operative condition with the boring bar of this invention another [the (b) Fig.] -- a configuration [like] is shown -- it is a fracture side elevation a part. In addition, except for the point that the connection configurations of the head section and the shank section differ, since the boring bar of these embodiments is the same as the above-mentioned example, it gives [drawing 1 R> 1] and a same sign to equivalent each part, omits explanation, and summarizes and explains ** to the difference point. [Drawing 3] (a) in the boring bar of a Fig. Head section (2) To the back end, it is the shank section (3). While preparing the disc-like mounting eye (2a) of the diameter of said Shank section (3) A coronary adapter (3a) is put at a tip, and it fixes, and they are two or more bolts (6) about those mounting eyes (2a) and adapters (3a). By minding and concluding, it is the head section (2). The shank section (3) is connected removable. Moreover, ** (b) With the boring bar of a Fig., it is the head section (2). To the back end

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Industrial Application] This invention is a thing which is used in case boring cutting is performed in a machine tool and which carries out boring bar Seki.

[Translation done.]

PRIOR ART

[Description of the Prior Art] With the boring bar used in case boring processing of the work piece is carried out in a machine tool, it becomes easy to generate chatter vibration at the time of processing, and this chatter vibration reduces the finishing precision of a work-piece processing side, or becomes with the cause of reducing the life of the cutting chip at the tip of a bar as the ratio of ejection die-length L from the fixed part of this bar to the path D of that bar, i.e., ratio of length to diameter, becomes large. Then, in the former, when ratio of length to diameter became large, generating of chatter vibration was avoided using the superhard bar which consists of rigid high cemented carbide material, various kinds of vibrationproofing bars which allotted the oscillating absorber and the vibrationproofing device to the body of a bar.
[0003] Moreover, in order to raise the rigidity of a boring bar as indicated by JP,5-39806,U, there are some which used fiber strengthening composite as an ingredient of the body of a bar. This boring bar (JP,5-39806,U) As shown in [drawing 5 R> 5], the chip section (21) which holds a chip at a tip It has the steel core (20) of the shape of a shaft which prepared the clamp section (22) in the back end side. To the perimeter between the chip section (21) of this steel core (20), and the clamp section (22), and carbon fiber reinforced plastic It considers as the configuration which covered the shell (23) which consists of (calling it CFRP for short hereafter). Since the rigidity of CFRP of the shell (12) is high, and the resonant frequency of the body of a bar is high since specific gravity is small, and CFRP is large compared with steel, the loss factor which shows a periodic-damping property The loss factor of the whole bar also becomes large compared with a steel bar, and is enabling control of chatter vibration by this.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As stated above, boring ** - concerning this invention can perform boring cutting of high process tolerance, without causing chatter vibration, even when high rigidity and a high loss factor can be secured to coincidence and ratio of length to diameter is therefore enlarged more.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, there are the following troubles in the boring bar by the above-mentioned conventional technique. That is, in said superhard bar, since the weight per unit volume of the cemented carbide material to be used is large, if a bar becomes a major diameter, while weight will become excessive, it becomes expensive. Moreover, at the time of use, the fine adjustment of said vibrationproofing bar is needed intricately [structure] at an expensive price.

[0005] On the other hand, the rigidity of the matrix material between fiber becomes to some extent low, and in the condition that shear deformation arises in a matrix material, fiber strengthening composites, such as CFRP, have the property that the loss factor of the fiber strengthening composite becomes large, when the own loss factor of a matrix material is large. Moreover, the shear deformation of this matrix material has the property that a core becomes large, in the direction of a cross section of this fiber strengthening composite. And the relation between the loss factor of fiber reinforced plastics own [when changing the dynamic modulus of longitudinal elasticity of the matrix resin of fiber reinforced plastics] and rigidity (dynamic modulus of longitudinal elasticity) has the remarkable fall of rigidity as shown in the graph of [drawing 4], when it has the relation of an inverse proportion mostly and a loss factor (periodic-damping property) is given highly, and when steel materials and the rigidity more than equivalent are given, the property that a loss factor falls remarkably has it. On the other hand, it is considering as the structure which covered the shell which becomes the perimeter of a steel core from fiber reinforced plastics with said conventional boring bar using fiber reinforced plastics, such as CFRP. Therefore, since steel exists in the cross-section core which becomes the largest [a shear strain] on structure, a loss factor cannot be raised effectively. Moreover, although rigidity of fiber reinforced plastics own [this] becomes low and the rigidity of the whole bar will be secured with a steel core when the fiber reinforced plastics which took the large loss factor are used in order to compensate this, since this core is in a cross-section core, its cross-section second moment will be low, and rigidity will become low. Therefore, with the structure of this conventional technique, when ratio of length to diameter is enlarged more, unless that rigidity and loss factor are raised collectively, the problem of it becoming impossible to suppress chatter vibration effectively occurs.

[0006] This invention aims at offering the boring bar which can control chatter vibration effectively, even when high rigidity and a high loss factor are securable for coincidence and ratio of length to diameter is therefore enlarged more in view of the trouble of the above-mentioned conventional technique.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention is considered as the following configurations. namely, the boring bar with which the boring bar concerning this invention comes to prepare the head section holding a cutting chip at the tip of the shaft-like shank section -- it is, said shank section is covered by the periphery of the body of the shape of a shaft which consists of fiber strengthening composite, and this body, and it is characterized by coming to have the enveloping layer which consists of high-elasticity material with a bending elastic modulus higher than said fiber strengthening composite.
[0008] Moreover, the above-mentioned enveloping layer shall consist of metal material.
[0009] Moreover, the above-mentioned enveloping layer shall consist of ceramic material.

[Translation done.]

OPERATION

[Function] As mentioned above, although a loss factor becomes large in the condition that shear deformation arises in the matrix material between fiber, fiber strengthening composite Since an inverse proportion is almost related, when a loss factor (periodic-damping property) is given highly, the loss factor and rigidity (dynamic modulus of longitudinal elasticity) Since the fall of a loss factor becomes remarkable when a rigid fall becomes remarkable and rigidity is raised conversely, if it remains as it is, a certain limitation produces rigidity and a loss factor to raise to coincidence. It sets to the boring bar of this invention here. Since the periphery of the body which consists of fiber strengthening composite of the shank section is covered with the enveloping layer which consists of high elasticity material with a bending elastic modulus higher than the fiber strengthening composite of this body The shear deformation of the matrix material of the fiber strengthening composite which constitutes this shank section body by restraining on the direction periphery of a cross section Since the rigidity of this fiber strengthening composite can be raised and the shear strain of the matrix material in the direction core of a cross section of this fiber strengthening composite is not restrained again Even when a large loss factor can also be taken, namely, the high rigidity of the shank section and a high loss factor can be secured to coincidence and ratio of length to diameter is therefore enlarged more, chatter vibration can be controlled effectively and a work piece can be cut with a sufficient precision.
[0011] Moreover, it is covering the periphery of the fiber strengthening composite which constitutes the body of the shank section with the enveloping layer which consists of metal material with a bending elastic modulus higher than this fiber strengthening composite, or ceramic material. An oil, water, etc. which are used at the time of cutting while high rigidity and a high loss factor are securable for coincidence as mentioned above, For the fiber strengthening composite concerned, the corrosion resistance improvement under an environment which problems, such as corrosion, produce can be aimed at, and fiber strengthening composite is protected from the damage which has occurred during cutting and depends ** etc. again, and extension can also plan useful life longevity.

[Translation done.]

EXAMPLE

[Example] The example of this invention is explained with reference to a drawing below. [drawing 1] the (a) Fig. shows the configuration of one example of the boring bar concerning this invention -- it is a fracture side elevation a part. [Drawing 1] The boring bar of this example shown in the (a) Fig. is a cutting chip (1) at the tip of the shaft-like shank section (3). The head section tabular [rectangular] to hold (2) It comes to prepare.
[0013] Moreover, the shank section (3) Body of the shape of a shaft which consists of a CFRP (carbon fiber reinforced plastic) (4) Enveloping layer which consists a periphery of metal material (5) It comes to cover. And this shank section (3) At a tip, it is the head section (2). It is attached by welding.
[0014] In this operation, roving which comes to bundle strengthening fiber the number of predetermined is first immersed in a resin tub. Matrix resin is infiltrated into this roving, this is inserted into the metallic conduit of predetermined thickness, and they are the outer diameter of 16mm, and die length. It forms in a 200mm stem. Subsequently Body of the shape of a shaft which consists of a CFRP by heating this by predetermined temperature and time amount in oven, and stiffening internal resin (4) About a periphery, it is the enveloping layer (5) of metal material. The shank section which it comes to cover (3) It formed. And this shank section (3) It is the head section (2) at a tip. It welded and formed in the boring bar of the above-mentioned configuration.
[0015] Moreover, body (5) CFRP is strengthening fiber. 49033MPa (50000kgf/mm2) Petroleum pitch system carbon fiber XN-50 (GURANOKKU by Nippon Oil Co., Ltd.), the coal pitch based carbon fiber K-135 (diamond lead by Mitsubishi Kasei Corp.), and PAN system carbon fiber M50B (Toray Industries, Inc. make trading card) which have a modulus of longitudinal elasticity were used. moreover -- matrix resin -- "Epicoat 87 (EPOSHIKI equivalent 430)" (shell company make) of EPOSHIKI resin, and a curing agent -- acid anhydride "Epiclon B570" (Dainippon Ink make) and imidazole "epicure EM-24" (shell company make) 100:27.0:2.8 what came out of comparatively and was mixed -- using -- this It heated for 30 minutes at 170 degrees C, and the hardening reaction was made to perform. The modulus of longitudinal elasticity of the strengthening fiber of this CFRP, the oscillation frequency of 1000Hz of matrix resin, a 25-degree C modulus of longitudinal elasticity, and a loss factor are shown in [Table 1].
[0016]
[Table 1]

	縦弾性率 MPa	損失係数 η
強化繊維	490333 (50000kgf/mm²)	——
マトリックス樹脂	167 (17kgf/mm²)	0.26

[0017] moreover, body (4) Enveloping layer (5) of a periphery ****** -- to a metallic conduit elastic modulus 205940MPa (21000kgf/mm2) -- thickness t 0.25mm and 0.35mm -- and -- The steel pipe (an equivalent for S45C) which is 0.5mm, and elastic modulus By 68647MPa

(7000kgf/mm2) Thickness t 0.5mm and 1.0mm And aluminum tubing (pure aluminum) which is 1.5mm was used. and these shanks section (3) ******** -- the tip -- the head section (2) Before welding, the following performed evaluation of the rigidity and loss factor.
[0018] The shaft-like shank section (3) It hit in the direction of bending by the boundary condition of both-ends freedom, and asked for the resonant frequency f of the primary bending using FFT (Ono Sokki CF 350) from the wave of the free vibration at that time. Moreover, body at this time (4) The dynamic modulus of longitudinal elasticity ECFRP of CFRP is the following. It asks by [1] formula.
ECFRP=16, 2, L4, and rhoCFRP/DCFRP 2-4.734 ---- [1] -- here, rhoCFRPs are [a diameter and L of the consistency of Above CFRP and DCFRP] die length.
[0019] And each shank section of this example (3) The dynamic modulus of longitudinal elasticity E is the following. It asked by [2] formulas.
E=1-/ICFRP- [(K-L3 / 4.734) - (EMETAL and IMETAL)] ---- [2] -- the shank section (3) in which K can be found from the above-mentioned primary measurement natural frequency f here A load rate, ICFRP, and IMETAL Body (4) CFRP and enveloping layer (4) the cross-section second moment of metal material -- it is -- these -- the following [3] - It asks by [5] formulas. Moreover, L is the shank section (3). Die length and EMETAL Enveloping layer (4) It is the dynamic modulus of longitudinal elasticity of metal material.
K=M (2 pi-f), 2 ---- [3] ICFRP=pi/DCFRP 4 / 64 ---- [4] IMETAL =pi- [(DCFRP+2t) 4-DCFRP4]/64 ---- [5] -- here -- M -- the shank section (3) mass and t -- said enveloping layer (4) ****** -- it is the thickness of the used metallic conduit.
[0020] On the other hand, it is each shank section (3) of this example. A loss factor eta asks for a logarithmic decrement delta from the wave of the above-mentioned free vibration, and is the following. It asked from the relation of [6] types.
eta=delta/pi ---- [6] -- while these results are shown in [[Table 2 and 3]] -- [drawing 1] The graph of the (b) Fig. is made to contrast with the thing of the conventional technique, and it is shown in it. In addition, the example which covered the body periphery which [Table 2] becomes from CFRP with the enveloping layer which consists of steel materials, and [Table 3] show the value of the example which covered this body periphery with the enveloping layer which consists of aluminum material, respectively. Moreover, the fiber volume fraction of CFRP is shown Vf% in these tables.
[0021]
[Table 2]

鋼材被覆シャンク部					
繊維体積含有率	Vf 55%			Vf 65%	
層厚さ mm	0.25	0.35	0.50	0.35	0.50
動的弾性率 MPa (参考 kgf/mm²値)	116072 (11836)	121073 (12346)	120475 (12285)	144089 (14693)	148100 (15102)
損失係数 η	0.15	0.14	0.12	0.15	0.13

[0022]
[Table 3]

アルミ材被覆シャンク部				
繊維体積含有率	Vf 55%			
層厚さ mm	0.5	0.75	1.0	1.25
動的弾性率 MPa (参考 kgf/mm²値)	108373 (11051)	116474 (11877)	120475 (12285)	122377 (12479)
損失係数 η	0.17	0.15	0.14	0.12

[0023] Moreover, [drawing 1] (b) the value plotted by the square mark in the graph of a Fig.

This example (it corresponds to [Table 2]) which covered with the steel-materials enveloping layer the body periphery.which consists of a CFRP,.and the value which plotted by the round mark The result of this example (it corresponds to [Table 3]) which covered this body periphery with the aluminum material enveloping layer is shown, respectively. Moreover, the plot of the trigonum mark The result of the example of the conventional technical **** comparison which covered the periphery of a steel core with the shell which consists of a CFRP is shown, and Curve A shows the value in the stem of the CFRP simple substance shown in the graph of [drawing 4].

[0024] in addition, the dynamic modulus E of the stem of a CFRP simple substance -- the above Second-moment ICFRP and IMETAL The following [7] -- and -- It is setting from [8] types and asks. [in / in the dynamic modulus E of the conventional technique which was searched for from [1] type and covered the steel core periphery with the shell of CFRP / the aforementioned [2] formula]

ICFRP=pi- [(DMETAL+2tCFRP) 4-DMETAL 4] / 64 ---- [7] IMETAL = pi-DMETAL 4/64 ---- [8] -- here -- DMETAL The diameter of a steel core and tCFRP are the thickness of CFRP shell.

[0025] [Table 2] [table 3] and [drawing 1] (a) As shown in the graph of a Fig., in the thing of this example, the big value which was impossible for the modulus of longitudinal elasticity and the loss factor with the conventional technique was realizable.

[0026] Subsequently, each shank section of above-mentioned this example (3) At a tip, it is the head section (2). While welding, it is this head section (2). Cutting chip (1) It attached, and considered as the boring bar of one body, and the following evaluation trials and boring cutting trials were performed about the boring bar (thing equipped with enveloping layer thickness 0.35mmm and the shank section with a diameter of 16mm) which has a steel-materials enveloping layer of them. Moreover, for the comparison, the boring bar furnished with the above, the same head section, and a cutting chip was prepared for the shank section of a carbon steel (S45C) simple substance with a diameter of 16mm, and the trial of the above and these conditions was performed in it.

[0027] First, it is the amount of ejection about the above-mentioned boring bar. 96mm It fixed by the support at one end carried out, and asked for the resonant frequency and loss factor in this condition. The measuring method of a natural frequency attached the acceleration sensor at the tip of a cutting chip, and asked for the natural frequency f of the primary bending using FFT (Ono Sokki CF 350) from the signal of a free vibration wave acquired by hitting the cutting chip tip in the direction of bending. Moreover, a loss factor eta is described above like said shank section. It asked from [6] types. The result is shown in [Table 4].

[0028]

[Table 4]

	固有振動数　Hz	損失係数　η
本実施例	９５０	０．１１
比較例	１１１２	０．０３

[0029] As shown in [Table 4], as for boring bar ratio **** of the example of a comparison which the boring bar of this example equipped with the shank section of a steel simple substance, and a natural frequency, the loss factor showed the value with this sharply as big level **** as about 4 times mostly.

[0030] Then, they are 300rpm and the amount of slitting about the rotational speed of a work piece with these boring bar (the amount of ejection of 96mm). 0.1mm and feed rate By the cutting conditions set to 0.08mmrev, the boring cutting trial was performed and the vibration acceleration at the tip of a cutting chip was measured. the result -- [drawing 2] the (a) Fig. -- and -- It is shown in the graph of the (b) Fig. In addition, the graph of the (a) Fig. of [drawing 2] is the boring bar of this example, (b) The graph of a Fig. shows the check ****** wave at the time of boring cutting with each boring bar of the example of a comparison.

[0031] [Drawing 2] (b) As shown in the graph of a Fig., the boring bar of the example of a comparison has started comparatively big check ******, and it was checked to this that the boring bar of this example has not caused chatter vibration, and can control effectively the chatter-by this vibration under boring cutting in the boring bar of this example as shown in the graph of the (a) Fig.
[0032] As stated above, in the boring bar of this example, by restraining the shear strain of the matrix material of CFRP which constitutes the body of the shank section by the enveloping layer of a periphery, high rigidity and a high loss factor could be realized to coincidence, the chatter vibration under boring cutting could be controlled effectively, and, thereby, the effectiveness which was excellent in this invention was able to be checked. furthermore , the corrosion resistance improvement under an environment which problems , such as corrosion , produce can aim at , and fiber strengthening composite protect from the damage which have occur during cutting and depend ** etc. again , and extension also plan useful life longevity for the CFRPs concerned , such as an oil use at the time of cutting , and water , by cover the periphery of CFRP which constitute a shank section body from a boring bar of this example with the enveloping layer which consist of a steel materials or an aluminum material .
[0033] In addition, with the boring bar of the above-mentioned example, it is a cutting chip (1). The head section to hold (2) Shank section (3) Although it joined by welding, this is one example, and it is the head section (2). Shank section (3) For example, by taking the structure shown in [drawing 3], it is connectable removable.
[0034] [drawing 3] the (a) Fig. -- and -- operative condition with the boring bar of this invention another [the (b) Fig.] -- a configuration [like] is shown -- it is a fracture side elevation a part. In addition, except for the point that the connection configurations of the head section and the shank section differ, since the boring bar of these embodiments is the same as the above-mentioned example, it gives [drawing 1 R> 1] and a same sign to equivalent each part, omits explanation, and summarizes and explains ** to the difference point. [Drawing 3] (a) in the boring bar of a Fig. Head section (2) To the back end, it is the shank section (3). While preparing the disc-like mounting eye (2a) of the diameter of said Shank section (3) A coronary adapter (3a) is put at a tip, and it fixes, and they are two or more bolts (6) about those mounting eyes (2a) and adapters (3a). By minding and concluding, it is the head section (2). The shank section (3) is connected removable. Moreover, ** (b) With the boring bar of a Fig., it is the head section (2). To the back end While preparing the same mounting eye (2a) as the above, it is the shank section (3). A disc-like adapter (3a') is welded at a tip, and they are two or more bolts (6) about those mounting eyes (2a) and adapters (3a'). Mind and by concluding The head section (2) Shank section (3) It has connected removable.
[0035] Moreover, at the above-mentioned example, it is the shank section (3). Body (4) While using CFRP (carbon fiber reinforced plastic), it is the body (4). Enveloping layer which consists a periphery of steel materials or aluminum material (5) Although covered this -- one example -- it is -- the body (4) **** -- highly [rigidity], as long as specific gravity is small and a loss factor is large, other fiber strengthening composites, for example, the fiber strengthening composite with which strengthening fiber consists of a metal fiber, a glass fiber, an aramid fiber, etc., may be used. Moreover, enveloping layer (5) It is a body (4) if it carries out. A bending elastic modulus may be higher than the fiber strengthening composite used, as long as it can restrain effectively the shear deformation of the matrix material of this fiber strengthening composite, alloy steel material and aluminum containing alloy material may be begun, for example, and to say nothing of using other metal material, not only metal material but the ceramics etc. may be used.
[0036] Moreover, at the above-mentioned example, it is the shank section (3). Body (4) Enveloping layer (5) It attaches for forming 1 body. matrix resin is sunk into roving which bundled strengthening fiber -- making -- this -- enveloping layer (5) It inserts into a metallic conduit and forms in a stem. ****** -- subsequently Body which consists of a CFRP by heating within oven and stiffening internal resin (4) It is the enveloping layer (5) of metal material about a periphery. The covered shank section (3) Although carried out Roving of strengthening fiber into which matrix resin was infiltrated in addition to this approach is inserted into the metal mold held at predetermined temperature, and this is drawn out at a predetermined rate. By hardening and the

drawing fabricating method to fabricate body (4) of the shape of a shaft which consists of fiber strengthening composite [finishing / hardening] forming -- this -- enveloping layer (5) ****** -- pressing fit in a metallic conduit -- or 1 body can also be formed by inserting and making it fix using adhesives, such as an epoxy resin. Moreover, body of the shape of a shaft which consists of fiber strengthening composite [finishing / hardening] (4) In order to obtain, the shaping approach which the one direction prepreg into which it sank in resin was fabricated by the rolling method etc., and the approach of pressurizing and stiffening by after that, for example, an autoclave etc., the approach of fabricating with a filament winding method, etc. could be adopted, and combined these shaping approach may also be beforehand applied in addition to the drawing fabricating method. Furthermore, body which consists of fiber strengthening composite [finishing / hardening] (4) About a periphery, it is an enveloping layer (5). In order to cover, it does not restrict to a metallic conduit and that of ** is also good in ceramic coating, hard chromium plating or ion plating, etc.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] it is the drawing in which the configuration, its loss factor, and dynamic modulus of one example of this invention are shown the part where (a) drawing shows a configuration -- fracture side elevation, (b) drawing is a graph which shows a loss factor and a dynamic modulus. [of a boring bar]
[Drawing 2] It is the graph which shows the check ****** wave at the time of the boring cut in connection with the boring bar of the example of this invention, The graph of (a) drawing is the boring bar of this example, The graph of (b) drawing is a graph which shows the check ****** wave at the time of the boring cut with each boring bar of the example of a comparison.
[Drawing 3] the configuration of another embodiment of the boring bar of this invention is shown -- it is a fracture side elevation a part.
[Drawing 4] It is the graph which shows the relation between the loss factor of fiber reinforced plastics own [when changing the dynamic modulus of longitudinal elasticity of the matrix resin in fiber reinforced plastics / this], and rigidity (dynamic modulus of longitudinal elasticity).
[Drawing 5] the configuration of the boring bar using the conventional fiber consolidation composite is shown -- it is a fracture side face a part.
[Description of Notations]
(1) -- Cut chip
(2) -- Head section
(3) -- Shank section
(4) -- Body
(5) -- Enveloping layer

[Translation done.]

* NOTICES *

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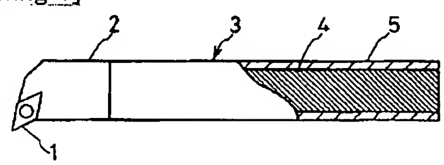
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]

(a)



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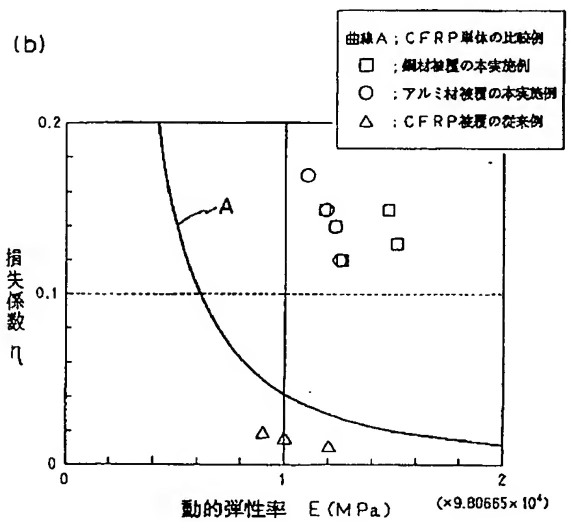
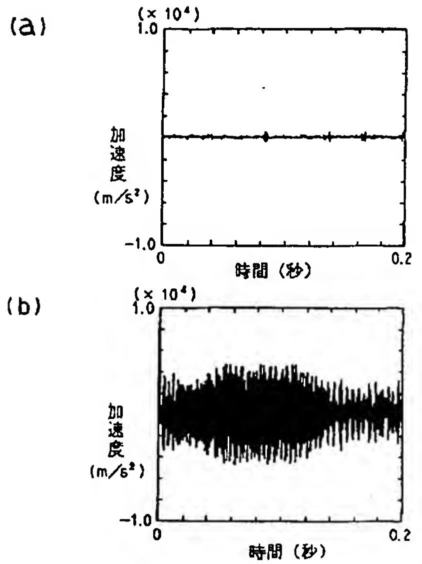
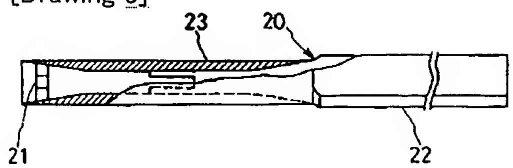


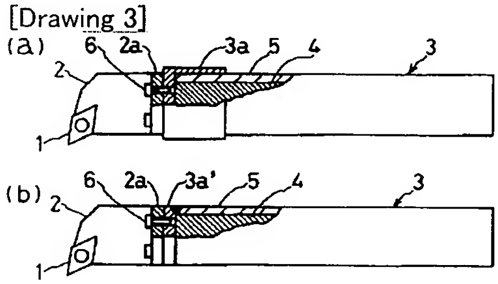
[Drawing 2]



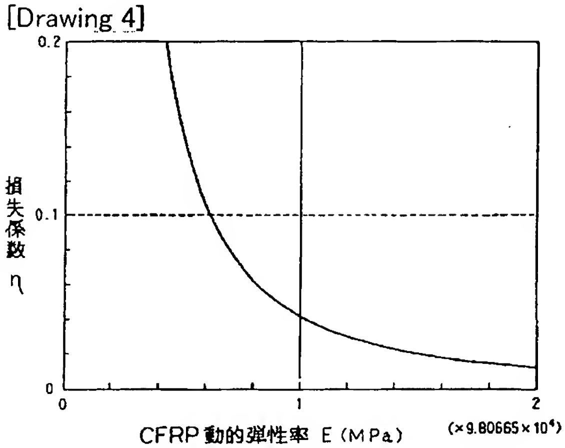
[Drawing 5]



[Drawing 3]

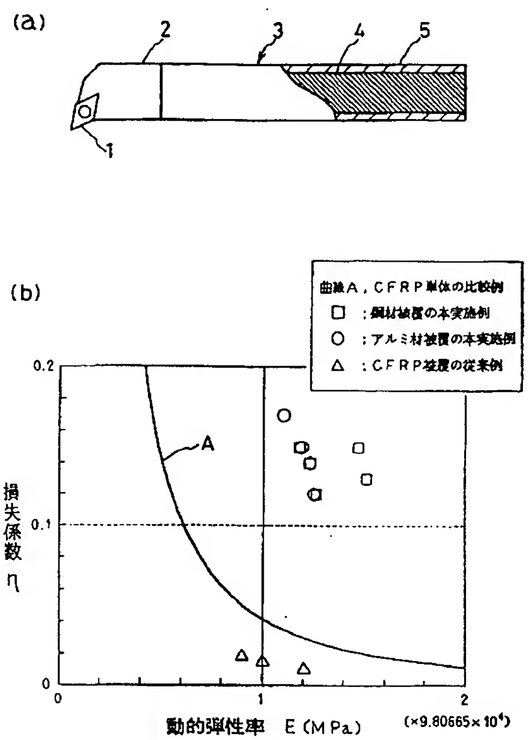


[Drawing 4]



[Translation done.]

Drawing selection Representative drawing



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JP7290305

Title:
BORING BAR

Abstract:

PURPOSE:To provide a boring bar capable of effectively suppressing chatter vibration and boring a work with high machining accuracy even when L/D is made larger. CONSTITUTION:This boring bar is provided with a head section 2 having a cutting tip 1 at the top of an axial shank section 3, and the shank section 3 is coated with a film layer 5 made of a steel material or an aluminum material having the bending elastic modulus higher than that of fiber reinforced plastic on the outer periphery of an axial main body 4 made of fiber reinforced plastic. The shear deformation of the plastic matrix material constituting the main body 4 of the shank section 3 is restrained by the film layer 5 on the outer periphery, and high rigidity and a high loss factor can be concurrently secured. Even when L/D is made larger, the occurrence of chatter vibration is suppressed, and a work can be bored with high accuracy.

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最終頁に続く

(54)【発明の名称】　ボーリングバー

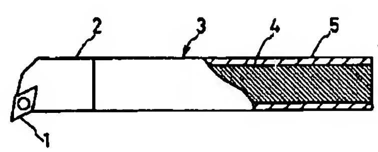
(57)【要約】

【目的】　Ｌ／Ｄをより大きくした場合でも、びびり振動を効果的に抑制でき、高い加工精度の中ぐり切削が行えるボーリングバーを得る。

【構成】　軸状のシャンク部(3) 先端に切削チップ(1)を保持するヘッド部(2)を設けてなるボーリングバーおいて、そのシャンク部(3) が、繊維強化プラスチックからなる軸状の本体(4) の外周を該繊維強化プラスチックよりも曲げ弾性率の高い鋼材やアルミ材等の被覆層(5)で被覆してなる構成とする。

【効果】　シャンク部の本体を構成するプラスチックのマトリックス材の剪断変形を、外周の被覆層で拘束することによって、高剛性と高損失係数とを同時に確保でき、よってＬ／Ｄをより大きくした場合でも、びびり振動の発生を抑えて、ワークを精度良く中ぐり切削することができる。

(a)



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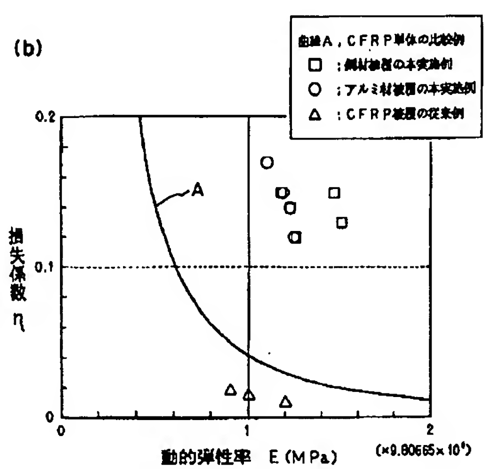


【特許請求の範囲】

【請求項1】　軸状のシャンク部の先端に切削チップを保持するヘッド部を設けてなるボーリングバーおいて、前記シャンク部が、繊維強化複合材からなる軸状の本体と、この本体の外周に被覆され、前記繊維強化複合材よりも曲げ弾性率の高い高弾性材からなる被覆層とを備えてなることを特徴とするボーリングバー。

【請求項2】　被覆層が金属材からなる請求項1記載のボーリングバー。

【請求項3】　被覆層がセラミックス材からなる請求項1記載のボーリングバー。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、工作機械において中ぐり切削を行う際に用いられるボーリングバー関するものである。

【0002】

【従来の技術】工作機械においてワークを中ぐり加工する際に用いられるボーリングバーでは、そのバーの径Dに対する該バーの固定部からの突き出し長さLの比、すなわちL／Dが大きくなるにつれて、加工時にびびり振動が発生し易くなり、このびびり振動が、ワーク加工面の仕上げ精度を低下させたり、バー先端の切削チップの寿命を低下させる原因となる。そこで従来では、L／Dが大きくなる場合には、剛性の高い超硬合金材からなる超硬バーや、バー本体に振動吸収材や防振機構を配した各種の防振バーなどを用いて、びびり振動の発生を回避していた。

【0003】また、実開平5-39806 号公報に開示されているように、ボーリングバーの剛性を高めるために、バー本体の材料として繊維強化複合材を用いたものもある。このボーリングバー（実開平5-39806 号）は、〔図5〕に示すように、先端にチップを保持するチップ部(21)を、後端側にクランプ部(22)を設けた軸状の鋼製コア(20)を有し、かつ、この鋼製コア(20)のチップ部(21)とクランプ部(22)との間の周囲に炭素繊維強化プラスチック（以下、ＣＦＲＰと略称する）からなるシェル(23)を被覆した構成とされており、そのシェル(12)のＣＦＲＰの剛性が高く、かつ比重が小さいことからバー本体の固有振動数が高く、かつＣＦＲＰは鋼に比べると振動減衰特性を示す損失係数が大きいので、バー全体の損失係数も鋼製バーに比べて大きくなり、これによって、びびり振動の抑制を可能としている。

【0004】

【発明が解決しようとする課題】しかし、上記従来技術によるボーリングバーでは、次のような問題点がある。すなわち、前記超硬バーでは、用いる超硬合金材の単位体積重量が大きいので、バーが大径になると重量が過大になると共に高価となる。また、前記防振バーは、構造が複雑でかつ高価であり、また使用時には細かな調整が必要となる。

【0005】一方、ＣＦＲＰ等の繊維強化複合材は、繊維と繊維の間のマトリックス材の剛性がある程度低くなり、マトリックス材に剪断変形が生じるような状態で、マトリックス材自身の損失係数が大きい場合、その繊維強化複合材の損失係数が大きくなるという特性がある。また、このマトリックス材の剪断変形は該繊維強化複合材の断面方向では中心部ほど大きくなる特性がある。そして、繊維強化プラスチックのマトリックス樹脂の動的縦弾性率を変化させた時の繊維強化プラスチック自身の損失係数と剛性（動的縦弾性率）との関係は、〔図4〕のグラフに示すように、ほぼ反比例の関係にあり、損失係数（振動減衰特性）を高く持たせた場合には、剛性の低下が著しく、また鋼材と同等以上の剛性を持たせた場合には、損失係数が著しく低下するという特性がある。これに対し、ＣＦＲＰ等の繊維強化プラスチックを用いた前記従来のボーリングバーでは、鋼製コアの周囲に繊維強化プラスチックからなるシェルを被覆した構造としている。従って、構造上最も剪断変形の大きくなる断面中心部に鋼が存在しているので、効果的に損失係数を高めることができない。また、これを補うために、損失係数を大きく取った繊維強化プラスチックを用いると、該繊維強化プラスチック自身の剛性は低くなり、鋼製のコアによってバー全体の剛性を確保することになるが、このコアは断面中心部にあることから断面2次モーメントが低く、剛性は低くなってしまう。そのため、この従来技術の構造では、L／Dをより大きくした場合、その剛性と損失係数とを併せて高めない限り、効果的にびびり振動を抑えることができなくなるという問題が発生する。

【0006】本発明は、上記従来技術の問題点に鑑み、高剛性と高損失係数とを同時に確保でき、よってL／Dをより大きくした場合でも、びびり振動を効果的に抑制できるボーリングバーを提供することを目的とする。

【0007】

【課題を解決するための手段】上記目的を達成するために、本発明は以下の構成とされている。すなわち、本発明に係るボーリングバーは、軸状のシャンク部の先端に切削チップを保持するヘッド部を設けてなるボーリングバーおいて、前記シャンク部が、繊維強化複合材からなる軸状の本体と、この本体の外周に被覆され、前記繊維強化複合材よりも曲げ弾性率の高い高弾性材からなる被覆層とを備えてなることを特徴とする。

【0008】また、上記被覆層が金属材からなるものとされても良い。

【0009】また、上記被覆層がセラミックス材からなるものとされても良い。

【0010】

【作用】前述のように、繊維強化複合材は、繊維と繊維の間のマトリックス材に剪断変形が生じるような状態

で、損失係数が大きくなるが、その損失係数と剛性（動的縦弾性率）とは、ほぼ反比例の関係あるため、損失係数（振動減衰特性）を高く持たせた場合には、剛性の低下が著しくなり、また逆に剛性を高めた場合には、損失係数の低下が著しくなるため、そのままでは剛性と損失係数とを同時に高めるにはある限界が生じる。ここで、本発明のボーリングバーにおいては、そのシャンク部の、繊維強化複合材からなる本体の外周を、該本体の繊維強化複合材よりも曲げ弾性率の高い高弾性材からなる被覆層で被覆しているので、このシャンク部本体を構成する繊維強化複合材のマトリックス材の剪断変形を、断面方向円周上で拘束することによって、該繊維強化複合材の剛性を高めることができ、かつまた、この繊維強化複合材の断面方向中心部でのマトリックス材の剪断変形は拘束していないので、損失係数も大きく取ることができ、すなわち、そのシャンク部の高剛性と高損失係数とを同時に確保でき、よってL／Dをより大きくした場合でも、びびり振動を効果的に抑制して、ワークを精度良く切削することができる。

【0011】また、そのシャンク部の本体を構成する繊維強化複合材の外周を、該繊維強化複合材よりも曲げ弾性率の高い金属材ないしはセラミック材からなる被覆層で被覆することで、上記のように高剛性と高損失係数とを同時に確保できると共に、切削時に用いられる油や水等の、当該繊維強化複合材にとって腐食等の問題が生じるような環境下における耐食性の改善が図れ、かつまた、切削中に発生する切りこ等よる損傷から繊維強化複合材を保護して耐用寿命を延長も図れる。

【0012】

【実施例】本発明の実施例について、以下に図面を参照して説明する。〔図1〕の (a)図は本発明に係るボーリングバーの1実施例の構成を示す一部破断側面図である。〔図1〕の (a)図に示す本実施例のボーリングバー＊は、軸状のシャンク部(3)の先端に切削チップ(1) を保持する方形板状のヘッド部(2) を設けてなる。

【0013】また、シャンク部(3) は、ＣＦＲＰ（炭素繊維強化プラスチック）からなる軸状の本体(4) の外周を、金属材からなる被覆層(5) で被覆してなる。そして、このシャンク部(3) の先端に、ヘッド部(2) が溶接によって取付けられている。

【0014】本実施では、まず、強化繊維を所定本数束ねてなるロービングを、樹脂槽内に浸潰して、このロービングにマトリックス樹脂を含浸させ、これを所定肉厚の金属管内に挿入して、外径16mm、長さ 200mmの軸状体に形成し、次いで、これをオーブン内において所定温度・時間で加熱して、内部の樹脂を硬化させることで、ＣＦＲＰからなる軸状の本体(4) の外周を、金属材の被覆層(5) で被覆してなるシャンク部(3) を形成した。そして、このシャンク部(3) 先端にヘッド部(2) を溶接して上記構成のボーリングバーに形成した。

【0015】また、本体(5) のＣＦＲＰは、強化繊維として 49033MPa(50000kgf/mm²) の縦弾性率を有する石油ピッチ系炭素繊維ＸＮ－５０（日本石油社製グラノック）、石炭ピッチ系炭素繊維Ｋ－１３５（三菱化成社製ダイアリード）およびＰＡＮ系炭素繊維Ｍ５０Ｂ（東レ社製トレカ）を用いた。また、マトリックス樹脂には、エポシキ樹脂の「エピコート８７（エポシキ当量４３０）」（シェル社製）、硬化剤には酸無水物「エピクロンＢ５７０」（大日本インキ社製）、イミダゾール「エピキュアＥＭ－２４」（シェル社製）を 100：27.0：2.8 の割合で混合したものを用い、これを 170℃で30分間加熱して、硬化反応を行わせた。このＣＦＲＰの強化繊維の縦弾性率、マトリックス樹脂の振動周波数1000Hz、25℃での縦弾性率および損失係数を〔表１〕に示す。

【0016】

【表1】

	縦弾性率　ＭＰａ	損失係数　η
強化繊維	４９０３３３ (50000kgf/mm²)	――
マトリックス樹脂	１６７ (17kgf/mm²)	０．２６

【0017】また、本体(4) の外周の被覆層(5) としての金属管には、弾性率が 205940MPa(21000kgf/mm²)で、厚さｔが 0.25mm 、0.35mmおよび 0.5mmの鋼管（S45C相当）と、弾性率が 68647MPa(7000kgf/mm²)で、厚さｔが 0.5mm、1.0mm および1.5mmのアルミ管（純アルミ）とを用いた。そして、これらシャンク部(3) について、その先端にヘッド部(2) を溶接する前に、以下により、そ※※の剛性と損失係数の評価を行った。

【0018】軸状のシャンク部(3) を両端自由の境界条件で曲げ方向に打撃を行い、その時の自由振動の波形からＦＦＴ（小野測器ＣＦ３５０）を用いて曲げ１次の固有振動数ｆを求めた。また、この時の本体(4) のＣＦＲＰの動的縦弾性率E_{CFRP}は、下記 [1]式で求められる。

$$E_{CFRP}=16\cdot(2\pi f_{CFRP})^2\cdot L^4\cdot\rho_{CFRP}/D_{CFRP}{}^2\cdot 4.73^4 \quad \text{---[1]}$$

ここで、ρ_{CFRP}は上記ＣＦＲＰの密度、D_{CFRP}は直径、Ｌは長さである。

【0019】そして、本実施例の各シャンク部(3) の動的縦弾性率Ｅは、下記 [2]式で求めた。

$$E=1/I_{CFRP}\cdot[(K\cdot L^3/4.73^4)-(E_{METAL}\cdot I_{METAL})] \quad \text{---[2]}$$

ここで、Kは上記測定1次固有振動数fから求まるシャンク部(3)のバネ定数、I_{CFRP}およびI_{METAL}は本体(4)CFRPおよび被覆層(4)金属材の断面2次モーメントであって、これらは下記[3]～[5]式で求められる。また、Lはシャンク部(3)の長さ、E_{METAL}は被覆層(4)の金属材の動的縦弾性率である。

$$K=M\cdot(2\pi\cdot f)^2 \quad \text{——[3]}$$

$$I_{CFRP}=\pi/D_{CFRP}{}^4/64 \quad \text{——[4]}$$

$$I_{METAL}=\pi\cdot[(D_{CFRP}+2t)^4-D_{CFRP}{}^4]/64 \quad \text{——[5]}$$

ここで、Mはシャンク部(3)の質量、tは前記被覆層(4)として用いた金属管の厚さである。

【0020】一方、本実施例の各シャンク部(3)の損失係数ηは、上記自由振動の波形から対数減衰率δを求め、下記[6]式の関係から求めた。

$$\eta=\delta/\pi \quad \text{——[6]}$$

これらの結果を、〔表2〕および〔表3〕に示すと共に、〔図1〕の(b)図のグラフに従来技術のものと対比させて示す。なお、〔表2〕はCFRPからなる本体外周を鋼材からなる被覆層で被覆した例、〔表3〕は同本体外周をアルミ材からなる被覆層で被覆した例の値をそれぞれ示す。また、これら表中のVf%は、CFRPの繊維体積含有率を示す。

【0021】

【表2】

鋼材被覆シャンク部					
繊維体積含有率	Vf 55%			Vf 65%	
層厚さ mm	0.25	0.35	0.50	0.35	0.50
動的弾性率 MPa (参考 kgf/mm²値)	116072 (11836)	121073 (12346)	120475 (12285)	144089 (14693)	148100 (15102)
損失係数 η	0.15	0.14	0.12	0.15	0.13

【0022】

【表3】

アルミ材被覆シャンク部				
繊維体積含有率	Vf 55%			
層厚さ mm	0.5	0.75	1.0	1.25
動的弾性率 MPa (参考 kgf/mm²値)	108373 (11051)	116474 (11877)	120475 (12285)	122377 (12479)
損失係数 η	0.17	0.15	0.14	0.12

【0023】また、〔図1〕の(b)図のグラフ中に、四角印でプロットした値は、CFRPからなる本体外周を鋼材被覆層で被覆した本実施例(〔表2〕に対応)、丸印でプロットした値は、同本体外周をアルミ材被覆層で被覆した本実施例(〔表3〕に対応)の結果をそれぞれ示し、また、三角印のプロットは、鋼製コアの外周をCFRPからなるシェルで被覆した従来技術よる比較例の結果を示し、曲線Aは、〔図4〕のグラフに示したCFRP単体の軸状体での値を示す。

【0024】なお、CFRP単体の軸状体の動的弾性率Eは前記[1]式から求められ、また、鋼製コア外周をCFRPのシェルで被覆した従来技術の動的弾性率Eは、前記[2]式における2次モーメントI_{CFRP}およびI_{METAL}を、下記[7]および[8]式から定めることで、求められる。

$$I_{CFRP}=\pi\cdot[(D_{METAL}+2t_{CFRP})^4-D_{METAL}{}^4]/64 \quad \text{——[7]}$$

$$I_{METAL}=\pi\cdot D_{METAL}{}^4/64 \quad \text{——[8]}$$

ここで、D_{METAL}は鋼製コアの直径、t_{CFRP}はCFRPシェルの厚さである。

【0025】〔表2〕、〔表3〕および〔図1〕の(a)図のグラフに示すように、本実施例のものでは、縦弾性率、損失係数共に従来技術では不可能であった大きな値を実現することができた。

【0026】次いで、上記本実施例の各シャンク部(3)の先端に、ヘッド部(2)を溶接すると共に該ヘッド部(2)に切削チップ(1)を取付けて1体のボーリングバーとし、その内の鋼材被覆層を有するボーリングバー(被覆層厚0.35㎜、直径16㎜のシャンク部を備えたもの)について、以下の評価試験と中ぐり切削試験を行った。また、比較のために、直径16㎜の炭素鋼(S45C)単体のシャンク部に上記と同じヘッド部と切削チップを取付けたボーリングバーを準備して、上記と同条件の試験を行った。

【0027】まず、上記ボーリングバーを、突き出し量を 96㎜ とした片持で固定し、この状態での固有振動数と損失係数を求めた。固有振動数の測定方法は、切削チップ先端に加速度センサを取付け、その切削チップ先端を曲げ方向に打撃することによって得られる自由振動波形の信号から、ＦＦＴ（小野測器ＣＦ３５０）を用いて曲げ１次の固有振動数 f を求めた。また、損失係数 η は、前記シャンク部と同様に前記［6］式から求めた。その結果を〔表４〕に示す。

【0028】

【表４】

	固有振動数　Hz	損失係数　η
本実施例	９５０	０．１１
比較例	１１１２	０．０３

【0029】〔表４〕に示すように、本実施例のボーリングバーは、鋼単体のシャンク部を備えた比較例のボーリングバー比べて、固有振動数はほぼ同レベルあるが、その損失係数は約４倍と大幅に大きな値を示した。

【0030】続いて、それらボーリングバーにて（突き出し量96㎜）、ワークの回転速度を300rpm、切り込み量を 0.1㎜、送り速度を 0.08㎜revとする切削条件で、中ぐり切削試験を行い、その切削チップ先端の振動加速度を測定した。その結果を〔図２〕の (a)図および (b)図のグラフに示す。なお、〔図２〕の(a)図のグラフは、本実施例のボーリングバー、 (b)図のグラフは比較例のボーリングバーそれぞれによる中ぐり切削時のびびり振動波形を示す。

【0031】〔図２〕の (b)図のグラフに示すように、比較例のボーリングバーは、比較的大きなびびり振動を起こしており、これに対して本実施例のボーリングバーは、(a)図のグラフに示すように、びびり振動を起こしてなく、これにより本実施例のボーリングバーでは、中ぐり切削中におけるびびり振動を効果的に抑制できることが確認された。

【0032】以上に述べたように、本実施例のボーリングバーでは、シャンク部の本体を構成するＣＦＲＰのマトリックス材の剪断変形を外周の被覆層で拘束することで、高剛性と高損失係数とを同時に実現できて、中ぐり切削中におけるびびり振動を効果的に抑制でき、これにより、本発明の優れた効果を確認することができた。更に、本実施例のボーリングバーでは、シャンク部本体を構成するＣＦＲＰの外周を、鋼材ないしはアルミ材からなる被覆層で被覆することで、切削時に用いられる油や水等の、当該ＣＦＲＰにとって腐食等の問題が生じるような環境下における耐食性の改善が図れ、かつまた、切削中に発生する切りこ等よる損傷から繊維強化複合材を保護して耐用寿命を延長も図れる。

【0033】なお、上記実施例のボーリングバーでは、切削チップ(1) を保持するヘッド部(2) とシャンク部(3) は、溶接によって接合したが、これは１例であって、そのヘッド部(2) とシャンク部(3) とは、例えば〔図３〕に示す構造を採ることで、着脱可能に接続することができる。

【0034】〔図３〕の (a)図および (b)図は、本発明のボーリングバーの別の実施態様の構成を示す一部破断側面図である。なお、これら実施態様のボーリングバーは、ヘッド部とシャンク部の接続構成が異なる点を除いて、上記実施例と同じであるので、等価な各部に〔図１〕と同符号を付して説明を省略し、その差異点にみを要約して説明する。〔図３〕の (a)図のボーリングバーでは、ヘッド部(2) の後端に、シャンク部(3) と同径の円盤状の取付座(2a)を設ける一方、シャンク部(3) の先端に冠状のアダプタ(3a)を被せて固着し、かつ、それらの取付座(2a)とアダプタ(3a)とを、複数のボルト(6) を介して締結することで、そのヘッド部(2) とシャンク部(3)とを着脱可能に接続している。また、同 (b)図のボーリングバーでは、ヘッド部(2) の後端に、上記と同様の取付座(2a)を設ける一方、シャンク部(3) の先端に円盤状のアダプタ(3a')を溶接し、かつ、それらの取付座(2a)とアダプタ(3a')とを、複数のボルト(6) を介して締結することで、そのヘッド部(2) とシャンク部(3) とを着脱可能に接続している。

【0035】また、上記実施例では、シャンク部(3) の本体(4) に、ＣＦＲＰ（炭素繊維強化プラスチック）を用いると共に、その本体(4) 外周を鋼材ないしはアルミ材からなる被覆層(5) で被覆したが、これは１例であって、その本体(4) には、剛性が高く、かつ比重が小さくて損失係数の大きいものであれば、その他の繊維強化複合材、例えば、強化繊維が金属繊維、ガラス繊維、アラミド繊維等からなる繊維強化複合材を用いても良い。また、被覆層(5) としては、本体(4) 用いられる繊維強化複合材よりも曲げ弾性率が高くて、該繊維強化複合材のマトリックス材の剪断変形を効果的に拘束できるものであれば、例えば、合金鋼材やアルミ合金材をはじめ、その他の金属材を用いて良いことは言うまでもなく、また、金属材に限らずセラミックス等を用いても良い。

【0036】また、上記実施例では、シャンク部(3) の本体(4) と被覆層(5) を１体化するについて、強化繊維を束ねたロービングにマトリックス樹脂を含浸させ、これを被覆層(5) としての金属管内に挿入して軸状体に形成し、次いで、オーブン内で加熱して内部の樹脂を硬化させることで、ＣＦＲＰからなる本体(4) 外周を金属材の被覆層(5) で被覆したシャンク部(3) としたが、この方法以外に、マトリックス樹脂を含浸させた強化繊維のロービングを、所定温度に保持された金型内に挿入し、これを所定速度で引き抜いて硬化・成形する引き抜き成形法によって、硬化済の繊維強化複合材からなる軸状の本体(4) を形成し、これを被覆層(5) としての金属管内

に圧入することで、ないしは挿入してエポキシ樹脂等の接着剤を用いて固着させることで1体化することもできる。また、硬化済の繊維強化複合材からなる軸状の本体(4) を得るには、引き抜き成形法以外に、予め樹脂の含浸された一方向プリプレグをローリング法等により成形し、その後例えばオートクレーブ等で加圧・硬化させる方法や、フィラメントワインディング法により成形する方法等を採用されて良く、また、これら成形方法を組み合わせた成形方法も適用されて良い。更に、硬化済の繊維強化複合材からなる本体(4) 外周を、被覆層(5) で被覆するには、金属管に限るものでなく、例えば、セラミックスコーテングや硬質クロームめっき、ないしはイオンプレーティング等を施のも良い。

【0037】

【発明の効果】以上に述べたように、本発明に係るボーリングばーは、高剛性と高損失係数とを同時に確保でき、よってL／Dをより大きくした場合でも、びびり振動を起こすことなく、高い加工精度の中ぐり切削を行うことができる。

【図面の簡単な説明】

【図1】本発明のボーリングバーの1実施例の構成とその損失係数および動的弾性率を示す図面であって、(a)図は構成を示す一部破断側面図、(b)図は損失係数および動的弾性率を示すグラフである。

【図2】本発明の実施例のボーリングバーに関わる中ぐり切削時のびびり振動波形を示すグラフであって、(a)図のグラフは本実施例のボーリングバー、(b)図のグラフは比較例のボーリングバーそれぞれによる中ぐり切削時のびびり振動波形を示すグラフである。

【図3】本発明のボーリングバーの別の実施態様の構成を示す一部破断側面図である。

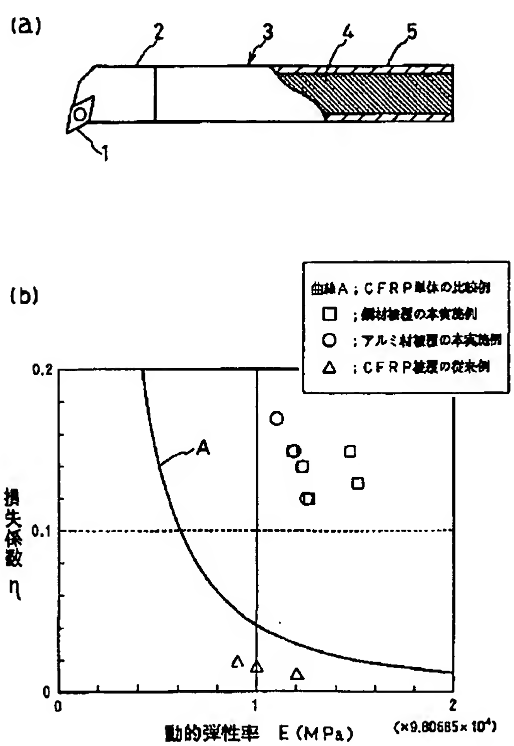
【図4】繊維強化プラスチックにおけるマトリックス樹脂の動的縦弾性率を変化させた時の該繊維強化プラスチック自身の損失係数と剛性（動的縦弾性率）との関係を示すグラフである。

【図5】従来の繊維強化複合材を用いたボーリングバーの構成を示す一部破断側面である。

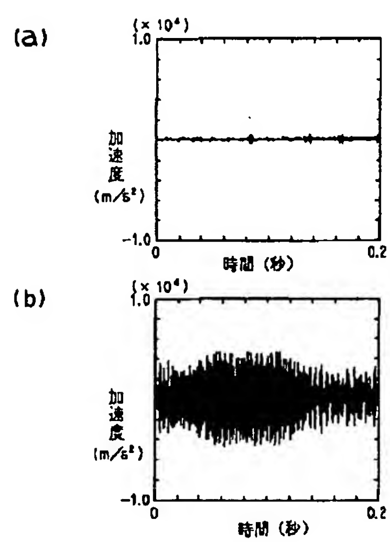
【符号の説明】

(1) 一切削チップ
(2) 一ヘッド部
(3) 一シャンク部
(4) 一本体
(5) 一被覆層

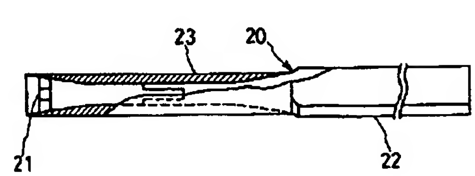
【図1】



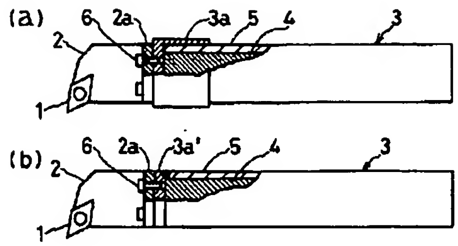
【図2】



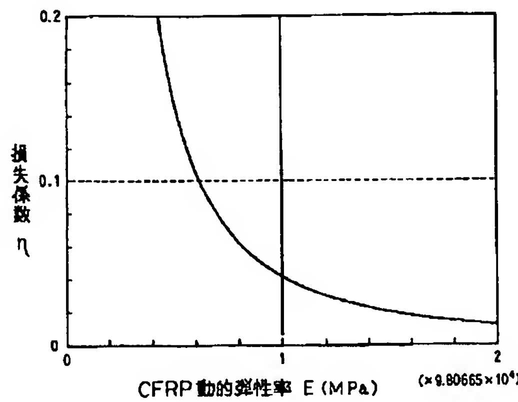
【図5】



【図3】



【図4】



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